Neural Networks in Machine Learning

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ABSTRACT
Machine Learning is associated with the study and construction of systems that can learn on their own rather than following instructions. It is used in search engines, optical character recognition, computer vision etc. Neural networks are one of the several techniques used in machine learning. Here we are trying to discuss neural network approaches used in machine learning.

General Terms
Types of neural networks

Keywords
Feed forward neural network, Radial basis function Kohonen's neural network, Recurrent neural network

1. INTRODUCTION
Neural network is constructed by connecting number of cells. These cells derive their input from one another. All the connections are weighted. Network has tuneable parameters [1]. Neural networks can be software based or hardware based but their functioning is inspired by neurons. They are useful for real time operations and adaptive learning. A simple neural network looks like follows:

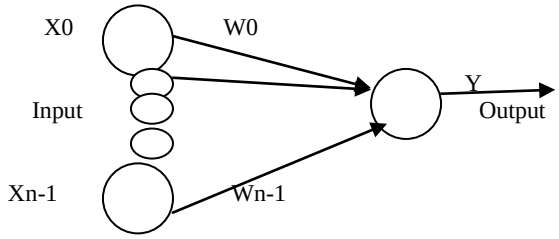

Fig.1 A simple neural network

2. TYPES OF NEURAL NETWORKS
Neural networks can be classified into following types:

2.1 Feed Forward Neural Network
Feed forward neural network contains all the neurons connected to previous layer neurons. Units in network are called nodes here. Data travels from one layer to another. It uses supervised learning [2].

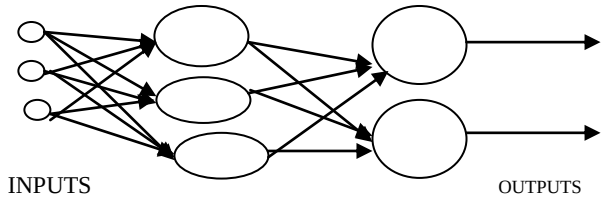

Fig. 2 Feed forward network

2.1.1 Advantage:
- Large number of nodes increase the storage capacity
- New information is stored by changing weights.
- Large number of nodes ensures that knowledge is robust and fault tolerance.
- Useful for data compression.
- Also used in pattern classification and object recognition.

2.1.2 Disadvantage:
- No feedback between layers
- Difference between actual and desired output produces an error.
- Training the network becomes an optimisation problem to minimize the error function.

2.2 Radial basis Function Neural Network
These are basically used in multidimensional space for interpolation. They work with two layers. First input is mapped onto RBF hidden layer. Performance is improved by use of regression techniques like ridge regression.

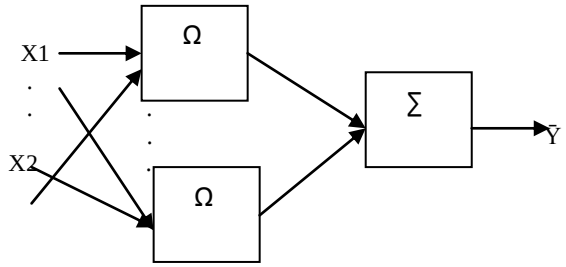

Fig. 3 Feed forward network

2.2.1 ADVANTAGE:
- It doesn't suffer from local minima.
- Only linear mapping is required from hidden layer to output layer.
- Training is faster.
- Hidden layer is easier to interpret.

2.2.2 Disadvantage:
- When training is finished and it is used it becomes slower.
- Good coverage of input space is required by radial basis function.
- Shrinkage method is required to avoid overfitting.
- Representational resources are wasted on areas of input space irrelevant to learning task.

2.3 Kohonen's Self-Organizing Neural Network
These are a type of unsupervised learning. In this network a topological structure is imposed on every node. That's why it is also called topology preserving map. Their most interesting aspect is that they learn how to classify without any supervision.

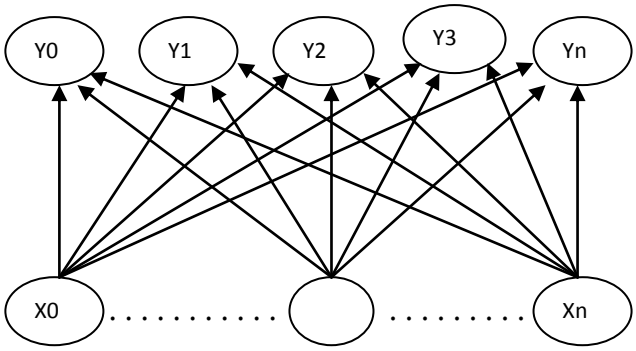

Fig. 4 Feed forward network

2.3.1 Advantage:

- The input space can have different dimensions from the output space.
- Input and output space can have different topologies.
- Learning process leads to well defined parameters for a given application.
- Neighbour units learn to react to closely related signal easily.
- They can be arranged in multidimensional grids.

2.3.2 Disadvantage:

- Other users and programs have to figure out how to interpret the output.
- Learning rate decreases with each epoch.
- During the later epochs size of neighbourhood around a cluster unit decreases.
- Second stages take much longer.

2.4 Learning Vector Quantization Neural Network

Such type of network has first competitive layer and second linear layer. Competitive layer learns how to classify input vectors and linear layer transforms the competitive layer's classes into target classes for classification defined by the user [3].

2.4.1 Advantage:

- It creates prototypes that are easy to interpret for specific domain expert.
- They can be applied to multiclass classification problems in a natural way.

2.4.2 Disadvantage:

- Choice of appropriate measure of distance is an issue.
- Generalization capacity decreases as hidden units are added.

2.5 Recurrent Neural Network

They are models with bi directional data flow. Neurons send feedback signals to each other. They also show dynamic temporal behaviour.

2.5.1 Advantage:

- It creates prototypes that are easy to interpret for specific domain expert.
- They can be applied to multiclass classification problems in a natural way.
- Arbitrary sequences of input can be processed easily by their internal memory.

2.5.2 Disadvantage:

- Choice of appropriate measure of distance is an issue.
- Generalization capacity decreases as hidden units are added.
- Training data needs to be in ordered sequence of input-output pairs.

2.6 Modular Neural Network

They constitute a series of neural networks. All of them are independent of each other. Each of them serves as a module and operates on independent input. Some intermediary is also used. It takes the output from each module and produces a single output of whole network.

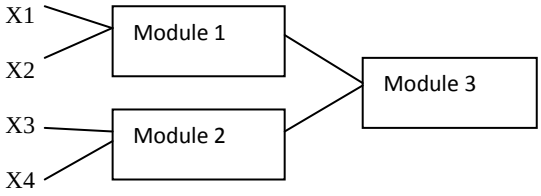

Fig. 5 Modular Neural Network Architecture

2.6.1 Advantage:

- It creates small network.
- Modules are easily manageable components.
- Subtasks execute more efficiently.
- Each network can be tailored according to task.
- Training algorithm can be implemented much more quickly.

2.6.2 Disadvantage:

- Connections that a node can make are limited.
- It can suffer from interference as new data sometimes alters existing connections.

2.7 Physical Neural Network

They use an electrical resistance material to perform the functions of a neural network. It is basically non linear and used to sum signals. One of its type called phase change has the potential to respond to multiple input signals [4].

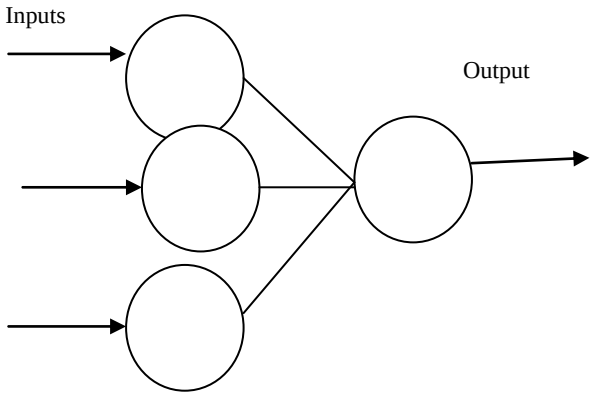

Fig. 6. ADALINE physical neural network

2.8 Time Delay Neural Network

They are meant to work on sequential data. It has no internal state. Input weight has a tap delay line associated with it. They can have finite dynamic response time to time series input data [5].

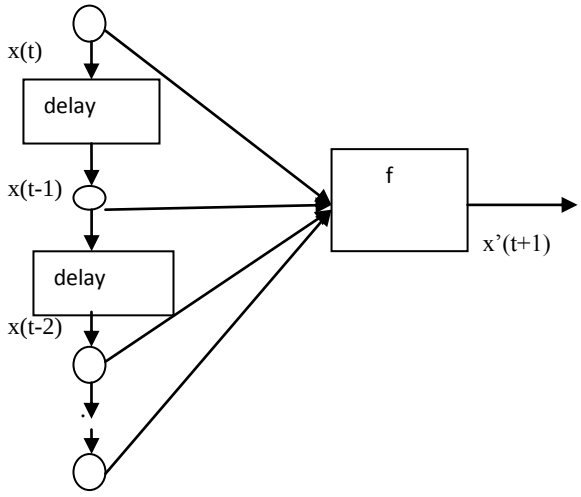

Fig. 7. Time delay neural network

2.8.1 Advantage:

- It can easily capture the dynamics of a system.
- They can foresee the output in a current time.
- They can produce a particular output pattern when a specific input sequence is seen.
- Just by seeing a part of the sequence they can generate rest of it too.
- They can produce a particular output sequence in response to a specific input sequence [6].
- They are used in pattern matching.
- They are useful in pattern matching algorithms.

2.8.2 Disadvantage:

- Their response in particular time is based on the inputs in that time.
- Their primary purpose is to work on sequential data only.

3. CONCLUSIONS

In this paper different neural networks with their advantages and disadvantages are discussed. Most general methods are linear or non linear. Then other broad categories are discussed.

Time delay neural networks have several advantages as compared to other most of the methods. What is common among all of them is connections between various nodes and training of all of them. Training time may differ from one network to another and to achieve efficient performance they can be combined with each other.

If time delay and modular networks are combined they can provide better results.

4. ACKNOWLEDGMENT

I have taken efforts in this research. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

I am highly indebted to Universal Group of Institutions for encouraging me to write a paper.

I would like to express my gratitude towards my parents for their kind co-operation and encouragement which help me in completion of this paper. My thanks and appreciations also go to people who have willingly helped me out with their abilities.

Last but not least I must thank God for the completion of my research.

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